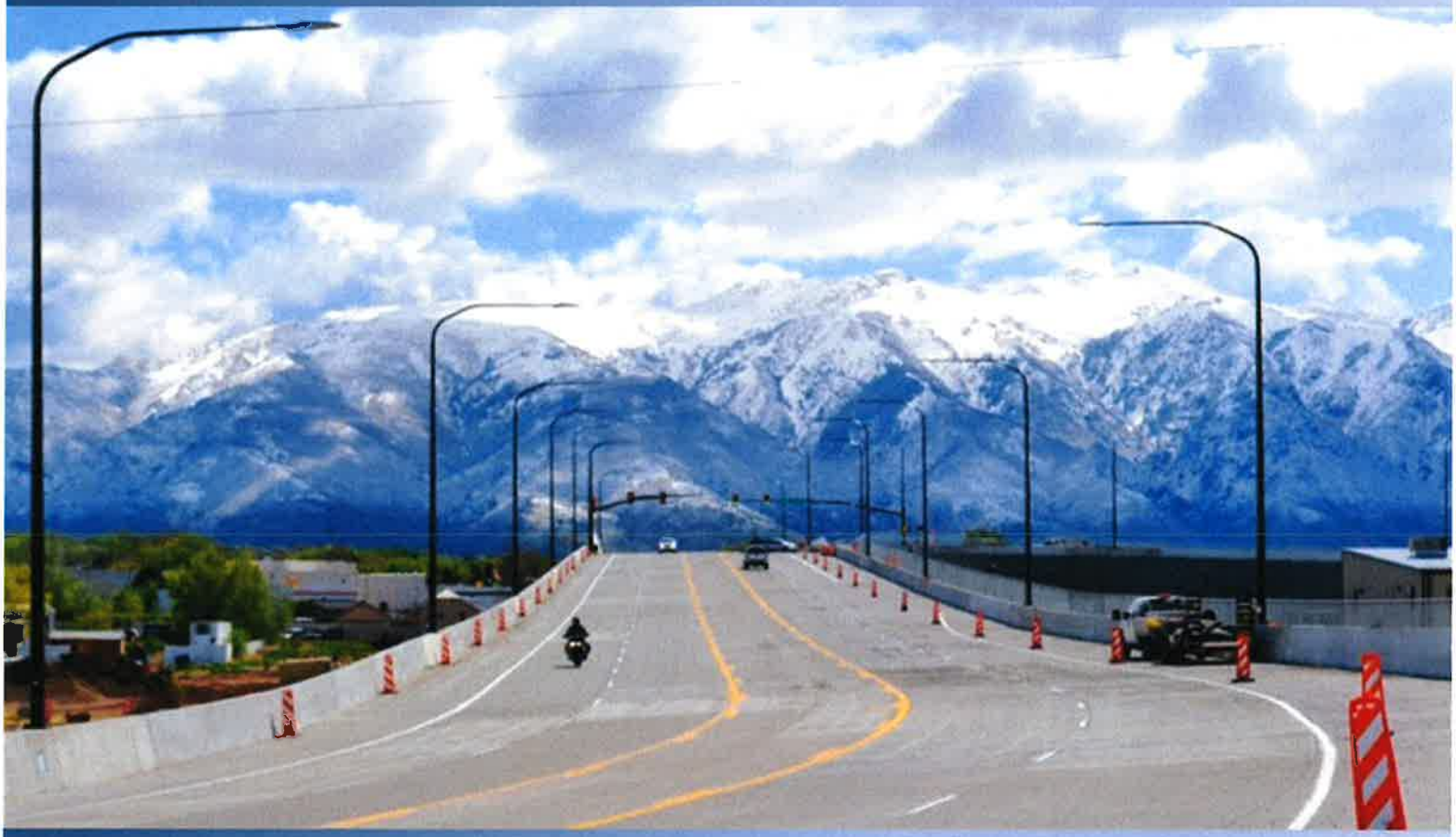
Roadway Lighting Design Guidelines



July 2018

UDOT

Keeping Utah Moving

1. OVERVIEW & CONSIDERATIONS

The Traffic and Safety Division of the Utah Department of Transportation has prepared this guideline as a tool for uniform understanding of the lighting design process. The purpose is to combine current design practices and standards into a single reference point to help foster accurate, efficient, and consistent lighting designs.

This guideline is intended to provide general design instruction to be applied in the lighting design process. Every lighting project will present a unique set of challenges and require a customized design. It is up to you, the designer, to apply sound engineering judgement, with the help of the project team, to provide an optimal design within your project's scope, schedule, and budget.

All design and construction work will follow the latest version of the UDOT Standard Specifications & Drawings, which will take precedence over any information presented in this guideline. This guideline will be updated on a regular basis. Check the UDOT website to ensure these guidelines are the latest version.

1.1. UDOT DESIGN PROJECT ORGANIZATION

All UDOT design projects require coordination with various individuals within and outside the Department. As a result, multiple individuals must be coordinated with for various needs throughout the lighting design process. The Project Definition Document (PDD) will define the specific project team and the relevant individuals and their positions. In general, the designer will route coordination through the UDOT Region Project Manager (PM) and, under the Region PM's direction, will coordinate with Region Staff and Central UDOT Traffic & Safety.

1.2. WARRANTING CONDITIONS

UDOT does not have a formal process to warrant lighting projects but there are many resources and factors to consider when providing lighting to a roadway or intersection. If the need should arise, engineers can support new lighting systems by including a warrant analysis as outlined in AASHTO's Roadway Lighting Design Guide (GL-6). Among the many potential warrants, the Lighting Design Guide includes ADT, night time to day time crash ratio, number of intersections within a given distance, urban/suburban density, and crash history. Typically, an official warrant does not factor in project development because the lighting plan has been

born out of local request, in response to apparent environmental conditions, or as an obvious requirement within a larger project. However, if lighting needs to be justified, AASHTO warrant criteria should be applied along with a safety analysis. If the warrant is specifically regarding crash history, the AASHTO Highway Safety Manual can be used to gather information on crash frequency and severity so lighting improvements can be quantified and evaluated in terms of effectiveness. Should crash data be required to warrant a lighting system, refer to UDOT's master crash data webpage:
https://dashboard.udot.utah.gov/SD-Base-Data-Sets/Master-Crash-Data/wc8h-8488/data

Other factors to consider that may warrant lighting along a roadway or an intersection include: local requests, pedestrian/cyclist crossings, socio economic factors, or just simple rural intersection location markers. Engineering judgement along with warrant studies and safety analyses should be utilized before designing and constructing any lighting project.

1.3. PROJECT DESIGN CRITERIA (PDC)

Prepare a PDC form for the project to establish the design criteria that will be followed. If your project is solely a lighting system installation, check with the region pre-construction engineer to determine if a PDC is needed. Prepare the PDC according to the latest guidelines as established in the UDOT Roadway Design Manual of Instruction and the UDOT Design Process Manual. Design criteria are established in the latest adopted applicable AASHTO, FHWA (MUTCD), and UDOT Standards as indicated on the PDC form. Use the PDC form to determine if any substandard criteria are being implemented or perpetuated with the project. These substandard items will need to follow the standard UDOT design exception, waiver procedures, and documentation. Complete the PDC early in the process because the design exception and waiver process may take a significant amount of time. Additionally, if the design deviates from other UDOT standards that are not a part of the PDC form, a "Deviation from UDOT Standards" document must be submitted and approved.

1.4. STATE FURNISHED MATERIALS

UDOT provides a significant portion of lighting materials as "State-Furnished." Refer to the State Furnished Items Form for the complete list of state furnished items. Part of the design process is determining the state furnished materials that will be needed. Periodic submittal (at each milestone) is required so that future stock

needs can be forecasted. Request reviews from the Region Signal and Lighting Engineer and Central Traffic and Safety prior to submitting the form. The final state furnished materials should be ordered as soon as possible and usually by the final design. Fill out the State Furnished Items form and submit as instructed on the form. Some special orders require 90 days, so it is imperative that materials are ordered well ahead of Notice to Proceed. Plan on a delay of about 4 to 6 weeks for steel powder coating.

1.5. PROJECT DELIVERY

Two main options are available for constructing UDOT lighting projects: Standard Project Advertisement and State Procurement Contract. Prior to assigning a designer, the Central Traffic & Safety Lighting Engineer and Region Signal Engineer should review the proposed project to determine which type of project delivery method should be used. They will also determine if Central Traffic & Safety Project funds are to be used or if a larger project should be submitting a request for funding by the region.

Standard Project Advertisement

Advertised projects include Design-Bid-Build, Construction Manager General Contractor (CMGC), and Design Build project delivery methods. These are the standard project delivery methods for most UDOT projects. These methods should be applied when the lighting project consists of one or more intersections, and may require right-of-way adjustments, utility relocations, roadway widening in excess of the procurement maximum contract amount ($60,000 in construction costs per project) or have other significant impacts. Federal projects must follow the advertisement project delivery process. Advertised projects will require complete bid documents, PDBS entries, and an advertisement checklist. The UDOT Plan Sheet Development Standards contain instructions for and examples of advertised signal plans.

State Procurement Contract

For time-critical projects or straight-forward lighting installations, UDOT can rely on a State Procurement Contract. This alternative for construction of lighting projects should be applied to projects with minimal issues. Lighting projects within the State Procurement system will not and cannot be expanded to resolve major problems with drainage, grading, roadway rehabilitation or widening, utility relocation, landscaping, and structures. The procurement contractors are electrical contractors

and have been selected based on their electrical experience. Most work is expected to fall within their area of expertise.

The contract is limited to lighting projects that are $60,000 or less in construction costs (as of 2018). Contact Central Traffic & Safety for signal procurement bid item prices to estimate in place of the PDBS estimate. It is important to note that procurement contractors are paid for the work they actually perform rather than quantities from an engineer's estimate that was prepared in the design phase. This virtually eliminates the need for change orders. In procurement, the purpose of preparing an estimate in design is to help ensure the project will fall within allocated funding.

The project will require abbreviated design plans with minimal special provisions, however the process is not as formal as advertisement, so adjustments can be made during construction. For state procurement contracts, adjust the design efforts to commensurate with the abbreviated plan set, and use standard procurement bid item names. Generally, procurement plans sets do not need right-of-way, survey control, typical sections, horizontal alignments, summary sheets, and maintenance of traffic sheets. The pre-selected procurement contractors have installed many lighting projects and will plan on working out some details in the field. Often, they will not need all the details provided to them since they have such extensive experience. However, be sure to work out all critical design elements during the design phase to avoid costly delays during construction.

Lighting procurement projects usually have a limited budget, scope, and schedule whose primary purpose is to install or upgrade lighting. Coordinate project needs with the Region Project Manager and prioritize as necessary. Attempt to limit the scope as much as possible to keep the project under its planned budget and schedule. If the project has more necessities than the budget and schedule allow, then communicate these needs early in the design process.

Check with the Central Traffic & Safety Design Engineer or the Region Project Manager for direction regarding which type of construction package you will be preparing prior to scoping a project. The lighting design process follows UDOT's standard Project Delivery Network. The actual project flow chart may vary depending on the size and scope of the project.

Environmental clearance and design exceptions (if needed) are necessary on procurement projects. Even though the state procurement delivery method allows

for abbreviated plans and design efforts it does not bypass the Environmental and Design Exceptions process. Environmental clearance through an Environmental Document, usually a Categorical Exclusion, must be obtained before construction begins. If there is a design exception, waiver, or deviation from UDOT standards it must be documented and approved through the same process as is required with an advertised project.

Survey / Base mapping

To further streamline simpler projects, the State Procurement Process may not require a full field survey with existing topography base mapping. In these cases, the lighting may be designed using to-scale aerial photography as the base map.

1.6. QC/QA

Regardless of the project delivery method, the latest UDOT Quality Control/Quality Assurance Procedures or an alternative approved QC/QA plan must be followed with associated required documentation. The checklists, check prints, and QA audit form will need to be uploaded to ProjectWise and properly attributed for the QC/QA process to be considered complete.

Comment Resolution Form

A key component of the QC/QA process is the Comment Resolution Form. The form can be obtained from UDOT's QC/QA page link above. Record all the comments and designer responses on the form. Note all comments made during site visits, review meetings, etc. Have one comment resolution form for the whole project so reviewers, managers, auditors, etc. can look back and tell how all the comments were addressed and the final design product was developed. Divide the form by milestone reviews (Scoping, PIH, PS&E, etc.).

Maintenance/Preconstruction Site Visit Certification Form

UDOT has added the Maintenance/Preconstruction Site Visit Certification Form to the advertising checklist. Each project must have a site visit with maintenance and fill out the form. The maintenance staff must sign the form. The purpose of the form is to "Ensure that a site visit and better communication occur between a project's design team and the maintenance stations affected by the project. Maintenance knows the roadway best and their on-site input for projects is crucial to fulfilling two of UDOT's strategic goals: preserve infrastructure and zero crashes, injuries, and fatalities."

2. FUNDING, OWNERSHIP, AND MAINTENANCE

2.1. UDOT ROADWAY LIGHTING POLICY

A significant part of highway lighting design is being familiar with UDOT's lighting policies. The ownership and funding of systems will factor in heavily with any design process you may encounter, so it will be important to establish this information up front. The lighting policy can be found online at:
https://www.udot.utah.gov/main/uconowner.gf?n=10464701670284919

2.2. STATE-OWNED SYSTEMS

Continuous freeway lighting

The majority of continuous freeway lighting is high mast lighting but can also be standard lighting in certain collector zones. Typically, these circuits will be 480V, and run from a state-owned transformer and pedestal.

FIGURE 2.2.1- CONTINUOUS FREEWAY LIGHTING

Freeway interchanges

This only includes areas with on and off ramps, and not local road overpasses. The freeway interchange circuit will include lighting at ramp gores, bridge underdecks, non-signalized intersections (rural areas), and areas along ramps that are determined to require lighting due to geometry or other safety reasons. For any signalized interchanges, lighting along the crossroad, with the exception of underdeck lighting, will stem from the traffic signal pedestal and will be the responsibility of the local municipality.

Freeway interchanges are not necessarily part of a continuous freeway. In some cases, a freeway-type interchange will be isolated along a state route with regular signalized intersections or rural highway in either direction. There have been examples of this along Bangerter Highway or US-6 in Helper or Price. Any freeway-type interchange lighting will be under State ownership unless otherwise arranged with the local municipality.

Rest Areas

Any State-run rest area will fall under state ownership regardless of where it is located. Examples of remote rest areas include the Bear Lake Overlook on US-89 or the US-191 Kane Springs picnic area south of Moab. These systems are typically 240V or less.

Ports of Entry

Lighting systems within a port of entry are State-owned but may have 240V systems even though they are in a freeway environment.

2.3. MUNICIPAL-OWNED SYSTEMS

Any state highway lighting system that does not fall under the definition of "State-owned" will belong to the local municipality. When designing these systems, there will be several considerations.

State-funded installations

100% State-funded lighting installations will use standard highway lighting poles and fixtures or approved high mast lighting and underdeck lighting. Wiring, junction boxes, pedestals, etc. will be specified in UDOT standards.

Cooperative Agreements

Some lighting plans, even those that are part of a larger roadway project, may involve funding from the local municipality. Typically, the local municipality has

requested an enhancement to the standard lighting plan that might include any of the following:

- Powder coating of standard light poles
- Decorative fixtures on standard light poles
- Banner arms or 120V outlets on standard poles
- City-standard light poles
- Non-standard decorative poles

The primary consideration in any lighting agreement is whether the State is providing funding. If the State has a stake in the lighting, then, regardless of the overall contribution, the lighting must be designed to meet the following:

- ANSI/IES RP-8-14 light levels as modified in this document in Appendix C
- Include a conscious effort at reasonable BUG ratings regarding fixture selection.

If the municipality has elected to fund the lighting in its entirety, then you may refer to city standards for junction box, wiring, pole/light fixture preferences, and pole spacing. Light levels and uniformity are generally not a consideration, but the city/municipality may want to optimize the design using their standard poles. Regardless of funding, the design must meet the following:

- Break-away poles within clear zones
- ADA requirements where sidewalks are involved
- Applicable NEC requirements
- And agree to maintain and provide power to the lighting units at no cost to UDOT

General Considerations

In any one of these cases, the local municipality will agree to provide funding for some or all of the particular enhancement. An official lighting agreement, usually written up by the UDOT project manager or utility coordinator, will detail responsibilities including materials sources and purchases, providing power supplies, and overall funding of the lighting plan. The agreement may also provide guidance on whether State or local municipality specifications will be used for construction.

3. STANDARD LIGHTING TYPES

3.1. STANDARD ROADWAY LIGHTING

UDOT standard roadway lighting consists of 30' or 40' mounting heights using galvanized steel slip-base-style poles with 10' or 15' davit arms. Refer to UDOT Standard Drawings SL 5A, B, & C for complete details.

Fixture options

UDOT uses 3 standard LED fixtures: Type A, Type B, and "local road/parking lot." All are state-furnished, but only certain Type A and Type B fixtures will be stocked in the warehouse. There are subtle differences between all these fixtures as noted in the table below:

TABLE 3.1.1-FIXTURE TYPES

Manufacture Designation*	Voltage	Watts	Lumen output	Color Temp	Distribution	PC	Color	Stock?
Type A								
RFM	480V	108W	12,218	4000K	Type III	No	White**	Yes
RFM	120-240V	108W	12,170	4000K	Type II	Yes	Gray	No
RFM	120-240V	108W	12,218	4000K	Type III	Yes	Gray	Yes
Type B								
RFL	480V	145W	17,361	4000K	Type II	No	White**	Yes
RFL	120-240V	145W	17,361	4000K	Type II	Yes	Gray	No
RFL	120-240V	145W	17,183	4000K	Type III	Yes	Gray	Yes
Local Road/Parking Lot								
RFS	120-240V	54W	5,590	3000K	Type III	Yes	Any	No

* Philips RoadFocus: "RFM" - RoadFocus Medium, "RFL" – RoadFocus Large, "RFS" – RoadFocus Small. ** All 480V fixtures should be white, including high mast, for easy voltage identification.

Fixture uses

Type A, Type III: Small signalized intersections, rural freeway ramp intersections, rural highway/local road intersection markers, certain continuous roadway lighting applications.

Type A, Type II: Rural or local continuous roadway lighting applications.

Type B, Type II: Freeway ramp gores, merge zones, arterial continuous roadway lighting.

Type B, Type III: Large signalized intersections, arterial continuous roadway lighting.

Local Road/Parking Lot: Rest area lighting, rural town intersections.

Mounting heights

Mounting heights are either 30' or 40' above the light pole foundation, depending on the constraints of each specific project due to overhead power, city lighting design plans, airport flight paths, or any other design constraint. The highway luminaire poles are supplied at 34'-9" and 24'-9" depending on the specific project documents. A highway luminaire arm with a 5'-6" rise and 10' or 15' reach will be placed on the pole achieving the nominal height of 30' or 40'. Both the pole and the arm are state furnished and should be accounted for in the project documents including the state furnished form and the SG-S03. Call-out the specific pole height, fixture type, and luminaire arm length on the plan sheet according to the Plan Sheet Development manual. All quantities must be accounted for in the summary sheets and the state furnished form.

3.2. HIGH MAST LIGHTING

High Mast lighting is any luminaire mounted over 45 feet and is mostly used along major freeways and their connection points with other major routes.

Figure 3.2.1-High Mast Lighting

Fixture Types

Type II – This fixture produces a long oval light distribution pattern and is used specifically for high mast racks with only 2 fixtures. These are typically in non-interchange, continuous roadway lighting sections of freeways.

Type V - This fixture produces a round, and somewhat forward-throw light distribution pattern and is used on high mast racks with 3 or more fixtures. These are typically employed at interchanges for increased light levels and as required lighting areas expands.

Mounting Heights

Although mounting height for high mast is any height above 45 feet, most high mast lighting will range from 80' to 120'. Greater mounting heights will typically require higher lumen output to maintain minimum average light levels. However increased mounting heights can allow for fewer poles and provide better uniformity.

Be mindful of navigable airspace during the design phase. Any design near an airport should reference local airport guidelines.

Mounting options

With standard UDOT contract high mast fixtures, between 2 and 5 are normally mounted on a given rack for most freeway applications. The contract does allow for purchases of non-standard fixtures, if needed.

3.3. UNDERDECK LIGHTING

As the name implies, underdeck lighting is used for roadways passing under bridge structures and is intended for general safety and/or to maintain consistent light levels with continuous roadway lighting. Most, if not all freeway underpasses will require underdeck lighting in some form, and these systems will be on the 480V state-owned lighting circuit. However, for non-interchange local routes passing under a freeway, the circuit must have its own separate routing and power source and will be the responsibility of the local municipality after construction is complete.

Fixture types

Wall packs - mounted to the bridge abutment or bent caps and are typically easy to access without traffic control.

Pendants - mounted to the bridge underdeck and are typically over the roadway. Pendants provide an easier way to provide minimum light levels, but require extensive traffic control in the event of a maintenance issue.

Consult the Region Traffic Operations Engineer before selecting either fixture in your design.

Mounting heights
Typically limited to the underside height of the bridge deck beams.

Mounting options
The preferred locations for underdeck lighting are anywhere outside live traffic lanes, such as along bridge abutments. However, these locations can be subject to vandalism, so conduit routing, shatter-resistant lenses, and vandal-resistant enclosures may be a consideration. Also, ensure that the conduit for the fixture be run to a junction box first, then a piece of flex pipe be routed to the fixture. This design allows the maintenance crews to be able to repair fixtures without removing conduit from both sides of the fixture.

Sign Lighting
Due to advanced reflectivity of sign sheeting, sign lighting is not used unless specifically requested by the Traffic Operations Engineer. If sign lighting has been requested for a location, contact the State Lighting Engineer to determine design options.

4. LED FIXTURE DESIGN FACTORS

Several factors come into play when choosing an LED fixture. Among these might include physical enclosure design regarding long-term durability, wiring arrangements for ease of installment, or actual light output to maximize pole spacing. The focus for this section is specifically about factors involving the light output

4.1. LIGHT DISTRIBUTION FACTORS

Efficacy

Defined as lumens of delivered light per watt of energy consumed. Most people would assume this to be the primary specification one might use to select a fixture, but that is not always the case.

Color Temperature

Not easily defined, but for the purposes of this document is a number expressed in Kelvin to determine how "warm" or "cool" a light source is in a typical range of 2500K to 6000K. A lower color temperature value is more yellowish/reddish or warm while the higher value will be more bluish or cool. The typical, unaltered LED chip will produce a very cool temperature around 5900K but can be treated to reduce it to warmer colors. Unfortunately, this treatment will also reduce the efficacy of the fixture, which can mean narrower pole spacing and therefore a higher pole count. Striking a balance between efficacy and color temperature should be a consideration depending on the location and purpose of the lighting. Lower temperatures could be more appropriate for low speed, downtown areas with pedestrian traffic, whereas a cooler temperature will work just as well in a high-speed freeway environment.

BUG Rating

A series of fixture output measurements to determine the level of typically unwanted light for development of an overall fixture rating. The individual ratings include backlight (B), uplight (U), and glare (G) and are typically expressed as 3 whole numbers such as "2-0-3." The higher the number, the higher the degree of light from that aspect. For standard UDOT lighting, U must be 0, but tolerance may be given to uplight (U) in decorative lighting applications. Although generally unavoidable, backlight (B) should be kept to a minimum unless it is advantageous for a particular application such as a business district. Glare (G) should always be minimized.

Light Distribution

There are 5 types of light distribution used for standard cobrahead lighting. High mast fixtures have an equivalent reference.

- Type I: A lateral distribution with a capsule shape having a preferred lateral width of 15 degrees.
- Type II: An oblong oval distribution used for narrow roadways
- Type III: An oval distribution used for wider roadways and intersections
- Type IV: A semicircular light meant for mounting on the sides of buildings and walls.
- Type V: A round distribution used for area lighting

4.2. LIGHT DISTRIBUTION IN DESIGN

The primary objective of lighting design is to put the light where we want it to be. As one might suspect, a quality fixture will distribute light to only the roadway, so when selecting a fixture consider the following:

- Pole spacing: What provides the best pole spacing in an optimized design?
- Spill light: Which fixture minimizes "spill light" or "light trespass"? Spill light is usually backlight, but can also be lateral forward light shed beyond the far side of the roadway.
- Glare: Which fixture minimizes glare? Glare is a significant factor when considering driver nighttime comfort
- Environmental comfort: Will there be a preference for warmer color temperatures?
- Light pollution: Has the municipality adopted a dark sky policy?

5. POWER SOURCES, TRANSFORMERS, PEDESTALS

5.1. POWER SOURCE & TRANSFORMERS

Contact the Region Utility Coordinator/Engineer to request a work order from the local serving power company and arrange a site meeting to verify the power source type and location. On the lighting plans, list the work order number (if applicable) and the name and phone number of the individual with whom the connection will be arranged. Also, identify the location of the power source graphically on the plans and indicate whether it is a pole or ground-mounted transformer. The service power source can be from an underground sleeve, a pole mounted transformer, or a ground-mounted transformer. Refer to Standard Drawing SL 4C through SL 4E for details.

Coordinate with the Region Utility Coordinator/Engineer regarding lighting agreement requirements with the local municipality. The local municipality will be responsible for utility bills related to intersection street lighting power and maintenance and any other arrangement identified in the agreement. List the contact person's name and phone number on the plans.

Remember to contact the Region Utility Coordinator/Engineer periodically during the design phase to coordinate the power service needs, and to assure work estimates have been approved.

5.2. UNDERGROUND SERVICE PEDESTALS

If the lighting is near a signalized intersection, locate the Underground Service Pedestal on either side and within 20 feet of the cabinet foundation. For a standalone lighting project, coordinate with the Signal Technician in the region the project is located to determine the best Underground Service Pedestal placement for future maintenance. The service pedestal is not state furnished and it is the contractor's responsibility to provide it following the STD DWG SL 4C. Specify single meter or dual meter for your specific project. At a signalized intersection, a dual meter is used when the lighting power consumption is paid by a local municipality and the traffic signal power consumption is paid by UDOT. Many times, a single meter is used for the intersection and the municipality pays a flat rate for the lighting power.

For lighting only projects, the meter is rated for 200 amps at 240 or 480 volts, the power company will often ask for this information while preparing the power source design. The Underground Service Pedestal will also contain a photocell that will control the lights.

Municipalities may have non-standard requirements for their lighting circuits. Coordinate with them and indicate the city requirements that do not meet the UDOT standards and specifications. Please fill out the design waiver forms and submit for signature and approval.

FIGURE 5.2.1 – UNDERGROUND SERVICE PEDESTAL

6. WIRE, CONDUIT, JUNCTION BOXES

6.1. WIRE TYPES

Wire should be selected based on voltage requirements which in all cases will be 480V or less.

Copper wire – Commonly specified for electrical circuits due to its high rate of conductivity and ease of use as it is more ductile than aluminum. Additionally, copper has fewer issues with oxidation, creep, and reactivity with other metals. However, copper is more expensive and has a high propensity for theft, so it is not always the first choice.

Aluminum wire – Requires extra care when splicing and grounding, so therefore can cause circuit continuity issues, especially long term. Aluminum is also susceptible to creep after years of heat cycles. Basically, aluminum expands and contracts substantially more than copper, and after repeated expansions and contractions, will eventually lose contact within a splice. As a result, it can only be used when specifically identified by the designer and approval from the highway lighting engineer. The advantage of aluminum is that it is lighter and easier to handle, rarely gets stolen, and is much cheaper to purchase.

Coatings - All wire should be coated with crosslinked polyethylene insulation so be sure to specify wire that meets the coating standard. Approval for deviation of standards will be required if coatings other than RHH-RHW2-USE2 or URD is specified.

Grounding – When using copper conductors, specify AWG #6 stranded ground wire per UDOT standard. If using aluminum, use AWG #4. Also, keep in mind that aluminum is reactive with copper, therefore details may be required to specify where or if aluminum/copper interfaces can be made.

6.2. WIRES SIZING

AWG- A minimum No. 8 AWG wire in circuits and luminaire poles is required, but for long runs, the voltage loss should be calculated to determine if a different wire size is required.

6.3. SPLICES

Splices for lighting should be limited as voltage loss will increase at these points. Wire should only be spliced in junction boxes and performed according to UDOT specifications.
Sealed, squid-type mechanical splices are required for all locations unless a local municipal specification allows for other methods. Mechanical splices are moisture-sealed with silicon grease and rubber boots and are usually rated for both copper and aluminum. A key component to good splices is to require the silicon grease be supplied and to specify that additional grease be applied at the time of installation.

Extra care must be taken when splicing aluminum wire since it will oxidize in the presence of air with very little exposure. This oxidation will inhibit contact within a splice. As a result, when aluminum wire is stripped for a splice, it must be greased, attached, and sealed as quickly as possible. Additionally, aluminum wire will creep after years of heat cycles, as mentioned in 6.1. This can be somewhat alleviated by clearly specifying a manufacturer's recommended splice bolt torque.

6.4. GROUNDING

Unless using aluminum, UDOT requires a single AWG No. 6 stranded copper ground wire in any conduit containing a 120 volt or higher circuit and for each highway lighting pole. This wire is grounded at each junction box along the associated lighting circuit. Refer to UDOT Standard Drawings SL series for details. Aluminum ground wire should match the wire size in the circuit.

6.5. CONDUIT

Material

PVC Schedule 40 & HDPE SDR11- Use schedule 40 PVC or SDR-11 HDPE, UL listed electrical conduit for underground conduit installation. PVC is commonly used in trenching applications and HDPE is required for directional boring. Use galvanized rigid steel or Schedule 80 PVC electrical conduit for above ground conduit installations. Never specify conduit diameter size less than 2 inches for lighting cables. Any pipe specified that does not meet the required minimum will require a design exception and appropriate approval.

Choosing the Right Conduit: The National Electric Code (NEC) requires no more than 40% of a conduit be filled with wire and cable. The cross-section of the wire (single conductor) or cable (multi conductor) varies depending on the type of insulation specified. 2-inch conduit for lighting should be more than sufficient in most cases. In rare multi-circuit situations, use the table below to assist with conduit sizing.

TABLE 6.5.1-CABLE CROSS SECTIONAL AREA

Wire Spec.	Cable Size	Cross-Sectional Area (sq. in.)
RHH-USE2-RHW2	No. 2	0.13
RHH-USE2-RHW2	No. 4	0.10

RHH-USE2-RHW2	No. 6	0.08
RHH-USE2-RHW2	No. 8	0.05
RHH-USE2-RHW2	No. 10	0.03

Placement

Conduit placement should be designed to avoid utilities but also take the shortest route for cost effectiveness. Placement outside of paved roadways can be done by trenching or directional boring. Each method must meet standard cover minimums as outlined in SL series standard drawings and Utah Administrative Rule 930-7.

6.6. JUNCTION BOXES

Placement

Pull Boxes should never be placed in the traveled way or on paved roadway shoulders. Keep them out of low areas to minimize impacts from water and debris. Always assure proper drainage, especially if the junction box will be embedded in a median barrier or other location where drainage may not be a primary consideration.

Material

Highway lighting junction box requirements follow the same polymer composite or polymer concrete specification as traffic signal junction boxes. Refer to UDOT Standard Drawing SL 4D for further details.

FIGURE 6.5.1 – STREET LIGHTING JUNCTION BOX

Size

Junction boxes can be either type A or B, both of which are different lengths and widths, but all are 24" deep. As the designer, you should designate in the project plans which junction box will be used. For standalone lighting, type A junction boxes

should be sufficient, but in instances where the box will be shared with other power consuming facilities, it may be necessary to use type B junction boxes.

Shared use
When boxes will be shared within a particular system such as a signalized intersection, signal, pedestrian and detection wiring circuits will not be combined in the same conduit as the lighting circuit. The separate circuits and corresponding conduits must be identified on the plans. The lighting circuit will always have its own conduit.

7. LIGHTING SYSTEM DESIGN

7.1. AGI32 LIGHTING DESIGN SOFTWARE

For projects with continuous roadway lighting or with large or complex interchanges, UDOT will require a lighting design analysis using AGi32 software. As a lighting designer, it will be important to familiarize yourself with this program and the outputs needed to confirm light levels will be met with your design.

The highway lighting design process is an iterative process that is quite effectively implemented by computer. If criteria are not initially satisfied, it will be necessary to change design parameters (e.g., pole spacing, mounting height, luminaire wattage, luminaire distribution) until an acceptable alternative is found. This process will be repeated until the design is optimized to meet the selected criteria.

For computerized designs prepared by outside consultants, the consultant will provide a complete lighting design file in electronic format. All lighting calculations shall be performed in AGi32 software.

7.2. RP-08-14 GUIDELINES

When developing light levels within your lighting design, always provide a balance or optimization between Luminance Method and Illuminance Methods. Use a Light Loss Factor (LLF) of 0.85.

Minimum average light levels
For recommendations on minimum light levels when using LED fixtures, please refer to Appendix C. Once the roadway type and conflicts have been defined, these numbers may be plugged into AGi32 to optimize pole spacing and light levels.

Uniformity
Uniformity is particularly important because the eye has trouble quickly adjusting to inconsistent light levels. Visibility is best when light levels along the roadway are consistent, with the exception of intersections where light levels increase due to increased levels of conflict.

7.3. MOUNTING HEIGHT & SPACING

These two factors are critical to optimizing lighting design. On a standard UDOT continuous roadway design, 40 foot poles in a staggered formation usually produce the best result. However, sometimes utility conflicts will require poles to be on one side of the roadway resulting in tighter pole spacing. For decorative lighting, if you are having trouble meeting uniformity, try different mounting heights or different distribution patterns.

7.4. FIXTURE SELECTION

As with mounting height and pole spacing, fixture selection can solve issues with average light level and uniformity. When optimizing, always look at both type 2 and type 3 light patterns as well as total lumen output to determine the best-case scenario.

7.5. GENERAL DESIGN FACTORS

Speed limit & clear zone
Determine the roadway clear zone based on the speed limit unless otherwise directed by the Region Traffic Operations Engineer. In most cases, poles will be placed within clear zones therefore requiring slip bases or other break-away type systems.

Town center zones
In town centers with low speed limits, on-street parking, buildings close to the roadway, and heavy pedestrian traffic, the clear zone rule may need a design

exception. If a vehicle hits a pole in this zone, having the pole break away may do more damage and cause more injury than if the pole stopped the car.

Pedestrian/cyclist volume

As demonstrated in Appendix C for average light levels, areas with higher pedestrian traffic should have more lighting. This can hold true for corridors with above average cyclist traffic or notable level of vehicle-cyclist incidents. There are ongoing studies being performed that reinforce the importance of providing lighting for pedestrian crossings. For most UDOT applications, pole mounted systems with mounting heights greater than 20 ft reduces glare and improve pedestrian visibility. For applications with a bollard luminaire (decorative lighting), it has been found that offsetting the luminaire 15 feet ahead of the pedestrian crossing improves visibility.

Airports

When the roadway passes near an airport, always check with the airport authority to determine maximum pole height within the flight corridor.

7.6. INTERSECTION DESIGN FACTORS

Signalized intersections

Signalized intersections should have a luminaire on every corner, regardless of crosswalks. If this is problematic due to overhead conflicts, then the focus should be on pedestrian queuing areas and crosswalks. Intersections without crosswalks should have a minimum 2 luminaires, preferably on opposite corners. Signalized intersections that are within a larger continuous roadway lighting system should be lit to 1.5 times the average light level of the continuous section.

FIGURE 7.6.1-SIGNALIZED INTERSECTION

Roundabouts

All entry/exit points should be well-lit. If the location is in a non-commercial area, residential area, or rural setting, the light levels should be more on the "local road" level to reduce potential for light pollution.

Railroad Crossings

Lighting at rail crossings is not required but should be discussed during project development. Light levels should follow the recommendations in RP-08-14 while taking into consideration local needs.

Thru -Turns

Appropriate lighting should be provided at conflict points for example: main crossing and U-turn crossover intersection within the Thru-Turn configuration to emphasize the presence of various users especially pedestrians. Depending on the intersection spacing and the level of lighting along the corridor additional lighting may be needed.

DDIs

Due to the presumed increase that wrong way movements will take place due to the unusual crossover design. Complete interchange lighting would be the preferred practice to implement for this type of interchange. If it is not feasible to implement a complete interchange lighting system, a partial interchange lighting system is recommended with focus on lighting the pedestrian pathways.

CFIs

For DDIs, it is desirable to light the main and crossover intersection similar to a signalized intersection. This will depend on the intersection spacing and the light levels for the road segment. Additional lighting could be added in the median to illuminate pedestrian refuge.

Spot safety improvements

Typically spot safety improvements arise from local requests or a proven history of vehicle incidents. Sometimes a single light pole will solve the problem. These issues are case-by-case, and usually require input from Region Traffic & Safety, representatives from the municipality, and local residents.

7.7. CONTINUOUS ROADWAY

Continuous roadway lighting is desirable for high-volume, multi-lane, multi-interchange freeways, or with multi-lane, multi-access, high pedestrian/cyclist state routes. Refer to Appendix C to determine appropriate light levels for the corridor conditions.

Standard roadway lighting

In a typical high-volume setting, these will be 40' mounting height with 15' arms, set on both sides of the road in staggered formation. The main thing to look out for is conflicts with the individual pole locations. Other things to consider are matching existing poles which may have shorter arms, or on narrower roadways, using a 30' mounting height.

High mast lighting

When designing high mast lighting, consider the following:

If the pole spacing is greater than 500', there should be an auxiliary wire pull box between poles. Junction boxes in median barrier will need some sort of drainage

When using a mounting height above 80', consider wind/weather conditions that may cause problems. Use UDOT contract fixtures for maintenance and appearance

consistency -- these will come in a variety of sizes and distributions for optimizing designs.

FIGURE 7.1.1-CONTINUOUS ROADWAY LIGHTING

Decorative

When working with decorative lighting, always recommend to the municipality to use fixtures with zero uplight and limited glare. If the fixture rating has numbers for uplight and glare, bring veiling luminance into the design for discussion. If the decorative lighting will be entirely paid for by the municipality, refer to the muni's standards for pole spacing, boxes, wiring and foundations. If UDOT funding is involved, a full lighting design will be required along with a review of pole breakaway and power circuit designs

7.8. UNDERPASSES

Freeway Underpass

Lighting levels should be similar to intersections on either side thus creating continuous, uniform roadway lighting. Be careful with the AGi32 program because the tendency is to inadvertently over light the underpass. For particularly long underpasses, daytime lighting may be a consideration. Underpass lighting should only be tied to the 480V circuit and be part of the freeway system when the location is an interchange.

Highway or Local Road

Non-interchange or non-freeway underdeck lighting should be on a separate 240V circuit (or voltage of local municipality preference) and will be the responsibility of the local municipality.

Bike Paths & Pedestrian Walkways

Longer bike path or pedestrian tunnels may require lighting and should be a point of discussion with the local municipality. This lighting should be relatively vandal-proof, having shatter resistant covers and tamper proof cages. Also try to embed the conduit in the wall or abutment rather than surface mount.

FIGURE 7.8.1-BIKE PATHS & PEDESTRIAN WALKWAYS

7.9. FREEWAY INTERCHANGE OPTIONS

Partial – Signalized

Partially lit signalized interchanges will include:

- Off ramp gore lighting with Type B LED luminaires (3 poles total: one pole at the gore point, and one pole each at approximately 230 feet in either direction)
- Pedestrian use roadways: Full ramp intersection lighting (4 luminaires minimum) with Type A luminaires. Use Type B luminaires for wider roadways with high traffic volumes.
- Non-pedestrian roadways: At least 2 Type A luminaires per ramp intersection.
- Provide crossroad underdeck lighting due to higher traffic volumes.

Partial – Rural

For remote rural interchanges that require lighting provide:

- Off ramp gore lighting with Type B LED luminaires (one pole at the gore point, and one pole each at approximately 230 feet in either direction)
- At least 2 Type A luminaires per ramp intersection.
- Crossroad underdeck lighting should be used, but may be optional.

Full interchange

With continuous freeway high mast lighting:

- Provide supplemental ramp intersection lighting in areas not meeting the criteria of this document.
- Underdeck lighting is mandatory

Without continuous freeway high mast lighting:

- Provide gore lighting at both on and off ramps.
- Provide lighting along merge areas of lane drops.
- Provide continuous roadway lighting along the crossroad, including underdeck lighting.

FIGURE 7.9.1-FREEWAY INTERCHANGE

7.10. TUNNELS

Good lighting should make driving through a tunnel like driving on the open road: it must allow drivers to enter, transit and exit the tunnel in safety and comfort. Light design for tunnels should allow the driver's eyes to adjust to the change in light.

8. INTEGRATION OF EXISTING SYSTEMS

8.1. SYSTEM INSPECTION

Inspection is critical for the integration of old systems into new improvements. The condition of each the pole, breakaway system, and its foundation should be inspected, noted, and discussed with the project manager if additional improvements need to be made. All conduit, wiring, and boxes should also be inspected. Arrange to meet with the region signal technician on-site to assist with the condition of the underground. Do not open any boxes or expose any wire without a licensed electrician or with a member of UDOT's signal team. The power source is often difficult to find for existing systems. During the on-site meeting with UDOT signal technician and freeway lighting team, explore the locations of the power source and ask the local power service company to meet you on-site to find the power source. Locations of the power sources are not often recorded in as-builts or have changed since the system was installed. Gather as much information as possible as it will be useful to the construction of the new system. Check the condition of the following:

- Poles, breakaway systems, foundations
- Conduit, wiring, boxes
- Power source, pedestal

8.2. DESIGN FACTORS

Pole height & spacing

Measure existing pole height and spacing of the existing system and check the light spread. Match the spacing if it fits the lighting requirements needed for the design corridor. Note the fixture type and match if it meets current standards and lighting needs.

9. WORK ZONE & TEMPORARY LIGHTING

Work zone and temporary lighting should be considered for construction zones requiring complex traffic maneuvers and where existing lighting will be removed or relocated. Flaggers stations should always be illuminated to provide a safe environment. Temporary roadway lighting should meet or exceed UDOT standard clear zone and lateral offset requirements, and should be evaluated for minimum light levels, glare, and light trespass.

During the initial phases of any project requiring relocation or removal of existing lighting, be sure to evaluate the location and discuss any potential issues with the project manager. If the design group deems temporary lighting necessary for any location, the project plan must provide specifics regarding lighting type, minimum light levels, locations, and responsibility for power and maintenance.

10. SOLAR LIGHTING

Solar lighting should be a consideration in remote rural areas or any location where access to power may be non-existent or cost prohibitive. Typically, these systems will run only with a lower wattage fixture and, consequently, a lower lumen output. But the location will also likely be isolated with no other light sources within miles, so lower light output will be desirable. When designing around solar lighting, do not plan on meeting the same minimum light levels as required in Appendix C. Poles and arms should be arranged to maximize the low light output to best address conflict points. Consult with a solar lighting supplier before proceeding with the design to best determine your options.

FIGURE 10.1.1-SOLAR POWER

APPENDIX A: GENERAL PLAN INSTRUCTIONS

Title Block

The four lines in the title block contain the following information:

The first line of each title block identifies the project name.
The second line of each title block identifies the project location
The third line of each title block is the project number and PIN
The fourth line identifies what information the sheet contains.

Fourth line examples:
ROADWAY
LIGHTING
LIGHTING CIRCUIT

Plan Sheet Numbering

Sheet numbering includes a letter code that identifies the type of sheet. The appropriate code letter is placed before the consecutive sheet numbering, e.g., RD-01, RD-02, RD-03, etc. Include only codes applicable to the lighting project and eliminate all others that are not needed.

Sheets beginning with a "1" (e.g. title, 1-A Index to Sheets, 1-B Abbreviations and Legend, etc.) do not require a sheet identification code. Follow the latest UDOT CADD Standards Guidelines when setting up a plan set.
Plan Sheets

For procurement plans sets it is important to remember to keep the number of plan sheets to a minimum. Use the plans to convey the most pertinent design information to the contractor. Keep in mind that the contractors on the procurement contract are very experienced signal and lighting installers and will often adjust the design in the field based on the conditions they encounter. An overabundance of plan sheets and design effort is a waste of the department's limited signal and lighting funds.

Every project will have a title sheet (Sheet 1). Often, especially on procurement projects, the index to sheets table will be placed on the title sheet. Otherwise the index to sheets will be made its own sheet (1-A). On procurement projects, there may be a short list of limitations to convey to the contractor. These limitations should be placed on the title sheet as well. If the limitations are extensive, then a

00555M specification could be prepared and included with the plans. No other special provisions are typically needed with a procurement project.

List the applicable supplemental drawings with the index to sheets. Depending on the size and scope of the lighting project there may also be an abbreviations and legend sheet, horizontal control sheet(s), cross reference sheet(s), and/or survey control sheet(s). Procurement projects do not typically include summary sheets or maintenance of traffic (MOT) sheets. Summary sheets are required on advertised projects.

APPENDIX B: AASHTO ROADWAY LIGHTING WARRANTING CONDITIONS

Continuous Freeway Lighting

Description. A continuous lighting system provides relatively uniform lighting on all main lanes and direct connections, and complete interchange lighting of all interchanges within the section. Frontage road are not normally continuously lighted. The lighting units may be conventional luminaires of high mast assemblies or both.

Continuous lighting may be warranted under one of the conditions described in the following table.

Table B-1 Warranting Conditions for Continuous Freeway Lighting (CFL)*

Case	Warranting Conditions
CFL-1	Sections in and near cities where the current average daily traffic (ADT) is 30,000 or greater.
CFL-2	Sections where three or more successive interchanges are located with an average spacing of 1.5 miles or less, and adjacent areas outside the right of way are substantially urban in character.
CFL-3	Sections of two miles or more passing through a substantially developed suburban or urban area in which one or more of the following conditions exist: A. Local traffic operates on a complete street grid having some form of street lighting, parts of which are visible from the freeway B. The freeway passes through a series of developments--such as residential, commercial, industrial and civic areas, colleges, parks, terminals, etc. that includes lighted roads, streets, parking areas, yards, etc.-- that are lighted C. Separate cross streets, both with and without connecting ramps, occur with an average spacing of 0.5 miles or less, some of which are lighted as part of the local street system D. The freeway cross section elements, such as median and borders, are substantially reduced in width below desirable sections used in relatively open country.
CFL-4	Sections where the ratio of night to day crash rate is at least 2.0 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. Where crash data are not available, rate comparison may be used as a general guideline for crash severity.

*AASHTO Table 3-2 Roadway Lighting Design Guide

Description. Complete interchange lighting is defined as a lighting system that provides a relative uniform lighting within the limits of the interchange, including:

- Main lines
- Direct connections
- Ramp terminal
- Frontage road or crossroad intersections.

Complete interchange lighting may be warranted under one of the following conditions described in the following table.

Table B-2. Warranting Conditions for Complete Interchange Lighting (CIL)*

Case	Warranting Conditions
CIL-1	Where the total current ADT ramp traffic entering and leaving the freeway within the interchange areas exceeds 10,000 for urban conditions, 8,000 for suburban conditions, or 5,000 for rural conditions.
CIL-2	Where the current ADT on the crossroad exceeds 10,000 for urban conditions, 8,000 for suburban conditions, or 5,000 for rural conditions.
CIL-3	Where existing substantial commercial or industrial development that is lighted during hours of darkness is located in the immediate vicinity of the interchange, or where the crossroad approach legs are lighted for 0.5 miles or more on each side of the interchange.
CIL-4	Where the ratio of night to day crash rate within the interchange area is at least 1.5 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. Where crash data are not available, rate comparison may be used as a general guideline for crash severity.

*AASHTO Table 3-3 Roadway Lighting Design Guide

Partial Interchange Lighting

Description. Partial interchange lighting is defined as a lighting system that provides illumination only of decision making area of roadways including:

- Acceleration and deceleration lanes
- Ramp terminals
- Crossroads at frontage road or ramp intersections
- Other areas of nighttime hazard.

Partial interchange lighting may be warranted under one of the conditions described in the following table.

Table B-3. Warranting Conditions for Partial Interchange Lighting (PIL)*

Case	Warranting Conditions
PIL-1	Where the current ADT ramp traffic entering and leaving the freeway within the interchange area exceeds 5,000 for urban conditions, 3,000 for suburban conditions, or 1,000 for rural conditions
PIL-2	Where the current ADT on the freeway through traffic lanes exceeds 25,000 for urban conditions, 20,000 for suburban conditions, or 10,000 for rural conditions.
PIL-3	Where the ratio of night to day crash rate within the interchange area is at least 1.25 times the statewide average for all unlighted similar sections, and a study indicates that lighting may be expected to result in a significant reduction in the night crash rate. Where crash data are not available, rate comparison may be used as a general guideline for crash severity.

*AASHTO Table 3-4 Roadway Lighting Design Guide

Special Considerations

Continuous, complete-interchange or partial-interchange lighting is considered justified where the local government agency finds sufficient benefit in the forms of convenience, safety policing, community promotion, public relations, etc. to pay an appreciable percentage of the cost of or wholly finance the installations, maintenance, and operations of the lighting facilities.

Where there is continuous freeway lighting, there should be complete interchange lighting. When continuous freeway lighting is warranted, but not initially installed, partial interchange lighting is considered justified under the continuous freeway lighting warrants CFL-1 or CFL-2. This would preclude the requirements of satisfying the partial interchange lighting warrants PIL-1 or PIL-2.

Where complete interchange lighting is warranted, but not initially fully installed, a partial lighting system that exceeds the normal partial installation in number of lighting units is considered justified.

Lighting of crossroad ramp terminals is warranted regardless of traffic volumes, where the design requires the use of raised channelizing or divisional islands, or where there is poor sight distance.

Bridges

It may be desirable to provide fixed source lighting on long bridges in urban and suburban areas even though the approaches are not lighted. On bridges without full shoulder, lighting enhances both safety and utility of bridges. Where bridges are provided with sidewalks for pedestrian movements, lighting is warranted for pedestrian safety and policing.

APPENDIX C: RECOMMENDED LIGHT LEVELS (ANSI/IES RP-8-14)

Freeway: Fully-controlled access roadway for through traffic. Examples are I-15, I-80, and I-84. This also includes freeway-style interchanges within expressways such as 7800 South Bangerter Highway.
Expressway: Roadway for through traffic with full or partial control of access via interchanges, intersections or roundabouts. Examples include SR-201 from I-15 to 5600 West and SR-92 in Utah County.
Major or arterial: Roadway primarily for high volume through traffic which include most, if not, all of urban sections of State Highway.
Collector: Although a collector is defined as a roadway feeding a major or arterial, this may be a classification to use for sections of highway passing through smaller towns or rural downtowns.
Local: A local is defined as a roadway feeding a collector or arterial but may be a consideration for rural locations where ambient light levels are preferred to be kept low.

Table C-1 Road Surface Classifications

Class	Q_o	Description	Mode of Reflectance
R1	0.10	Portland Cement Concrete road surface. Asphalt Road surface with a minimum of 12 percent of the aggregates composed of artificail brightener (e.g. Synopal) aggregates (e.g. laboradite, quartzite)	Mostly Diffuse
R2	0.07	Asphalt road surface with an aggregate composed of a minimum 60 % gravel (size greater than 1cm). Asphalt road surface with 10 to 15 % artificial brightner in aggregate mix. (Not normally used in North America)	Mixed (diffuse and specular)
R3	0.07	Asphalt road surface (regular and carpet seal) with dark aggregates (e.g. trap rock, blast furnace slag); rough texture after some months of use (typical highways).	Slightly Specular
R4	0.08	Asphalt road surface with very smooth texture	Mostly Specular

ANSI/IES RP-8-14 pg. 5

Table C-2 Luminance Method - Recommended Values (for roadway only)

Road/Street	Classification	Pedestrian Area Classification	Avg. Luminance L_{avg} (cd/m^2)	Avg. Uniformity Ratio L_{avg}/L_{min}	Max. Uniformity Ratio L_{max}/L_{min}	Max. Veiling Luminance Ratio $LV_{max}L_{avg}$
Road	Freeway Class A	N/A	0.6	3.5	6.0	0.3
	Freeway Class B	N/A	0.4	3.5	6.0	0.3
	Expressway	N/A	1.0	3.0	5.0	0.3
Street	Major	High	1.2	3.0	5.0	0.3
		Medium	0.9	3.0	5.0	0.3
		Low	0.6	3.5	6.0	0.3
	Collector	High	0.8	3.0	5.0	0.4
		Medium	0.6	3.5	6.0	0.4
		Low	0.4	4.0	8.0	0.4
	Local	High	0.6	6.0	10.0	0.4
		Medium	0.5	6.0	10.0	0.4
		Low	0.3	6.0	10.0	0.4

ANSI/IES RP-8-14 pgs. 12 and 13

Table C-3 Illuminance Method - Recommended Values (for intersections)

Illumination for Intersections				
Functional Classification	Average Maintained Illumination at Pavement by Pedestrian Area Classification in Lux/fc			Eavg/Emin
	High	Medium	Low	
Major/Major	34.0/3.4	26.0/2.6	18.0/1.8	3
Major/Collector	29.0/2.9	22.0/2.2	15.0/1.5	3
Major/Local	26.0/2.6	20.0/2.0	13.0/1.3	3
Collector/Collector	24.0/2.4	18.0/1.8	12.0/1.2	4
Collector/Local	21.0/2.1	16.0/1.6	10.0/1.0	4
Local/Local	18.0/1.8	14.0/1.4	8.0/0.8	6

ANSI/IES RP-8-14 pg. 15

Table C-4 Illuminance Method- Recommended Values (for isolated intersections)

Road Classification	Pavement Classification			Uniformity Ratio Eavg/Emin
	R1 Lux/fc	R2 & R3 Lux/fc	R4 Lux/fc	
Roadway Lighting				
Freeway Class A	6.0/0.6	9.0/0.9	8.0/0.8	3.0
Freeway Class B	4.0/0.4	6.0/0.6	5.0/0.5	3.0
Expressway	6.0/0.6	9.0/0.9	8.0/0.8	3.0
Street Lighting				
Major	6.0/0.6	9.0/0.9	8.0/0.8	3.0
Collector	4.0/0.4	6.0/0.6	5.0/0.5	4.0
Local	3.0/0.3	4.0/0.4	4.0/0.4	6.0

ANSI/IES RP-8-14 pg. 19

APPENDIX D: REFERENCES AND RESOURCES

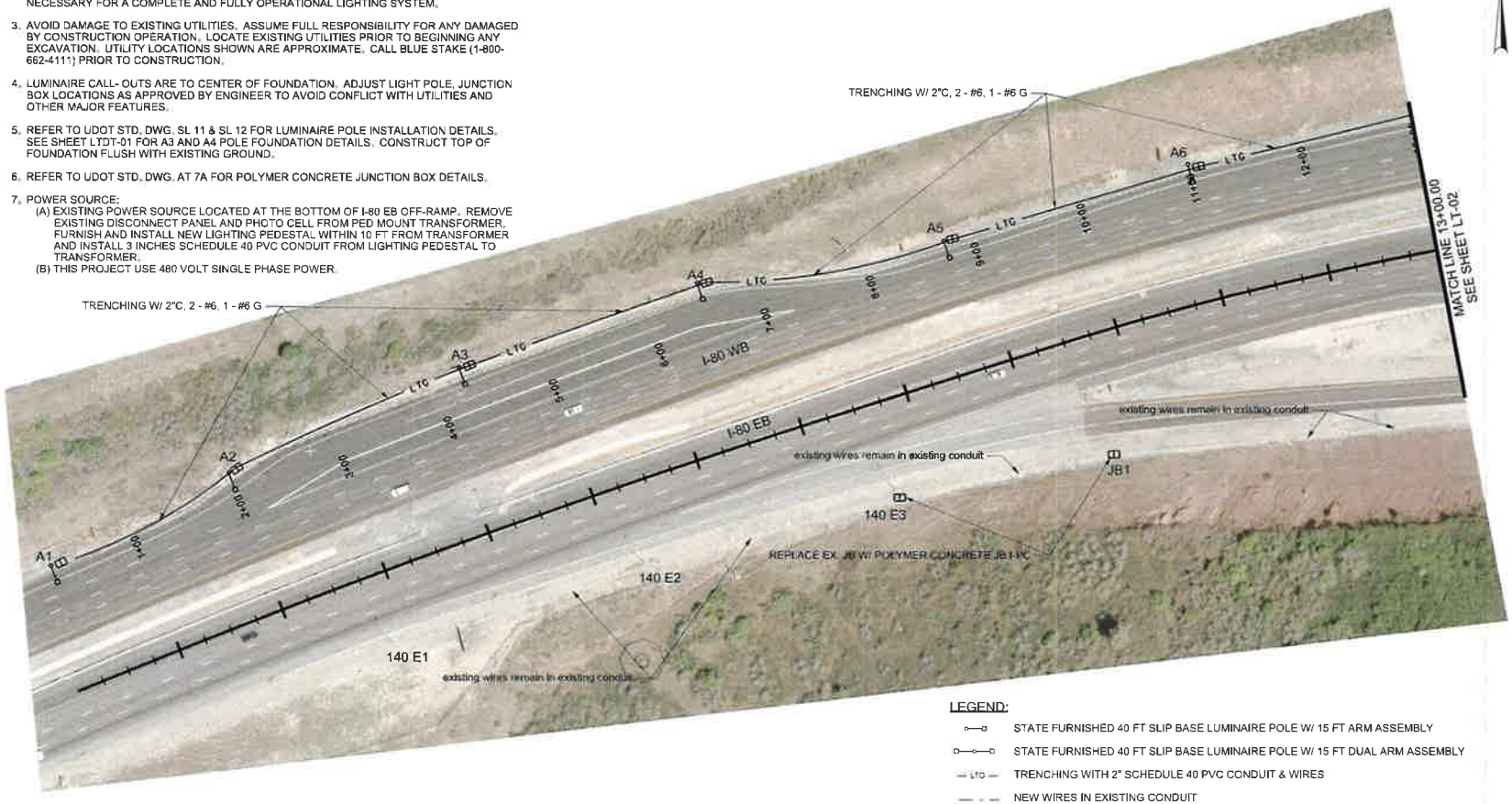
1.	Roadway Lighting Design Guide	GL-6	2010	AASHTO
2.	Roadway Lighting	RP-8-14	2014	ANSI/IES
3.	Roadside Design Guide		2011	AASHTO
4.	Lighting for Exterior Environments	RP-33-14	2014	IES
5.	Tunnel Lighting	RP-22-11	2011	ANSI/IES
6.	Recommended Practice for Lighting Maintenance	RP-36-15	2015	IES/NALMCO
7.	FHWA Lighting Handbook		2012	FHWA
8.	Design Criteria for Roadway Lighting	HRT-14-051	2012	FHWA
9.	Guidelines for the Implementation of Reduced Lighting on Roadways	HRT-14-050	2014	FHWA
10.	UDOT 2017 Standard Drawings		2017	UDOT
11.	UDOT 2017 Standard Specifications		2017	UDOT
12.	Utah MUTCD		2011	UDOT
13.	Highway Lighting Policy	06C-06	2016	UDOT
14.	Highway Lighting Procedures	06C-06.1	2016	UDOT
15.	Lighting Procurement Contract		2016-2019	UDOT

APPENDIX E: PROCUREMENT SAMPLE LIGHTING PLAN

LT and LTDT sheets. There are including lighting notes, legend, lighting schedule and pole foundation detail.

LIGHTING NOTES:

1. 40 FT SLIP BASE LUMINAIRE POLES, 15 FT SINGLE AND DUAL ARMS, ANCHOR BOLTS AND 480 VOLT LED TYPE 8 LUMINAIRES ARE STATE FURNISHED MATERIALS. CONTRACTOR IS RESPONSIBLE FOR INSTALLING STATE FURNISHED MATERIALS PER PLANS. CONTRACTOR ALSO FURNISH LOADING EQUIPMENT AND PERSONNEL TO PICK UP STATE FURNISHED MATERIALS FROM UDOT WAREHOUSE. CONTACT GREG PALMER AT (801) 965-4256, MINIMUM 48 HOURS IN ADVANCE, TO SCHEDULE PICK UP.
2. CONTRACTOR IS RESPONSIBLE FOR FURNISHING AND INSTALLING CONDUIT, CONDUCTORS, JUNCTION BOXES, 3/4" X 10' GROUND RODS, LIGHTING PEDESTAL SPECIFIED ON THE PLANS. REFER TO SHEET LT-06 FOR DETAILS. INCLUDES ALL WORKMANSHIP AND MATERIALS NECESSARY FOR A COMPLETE AND FULLY OPERATIONAL LIGHTING SYSTEM.
3. AVOID DAMAGE TO EXISTING UTILITIES. ASSUME FULL RESPONSIBILITY FOR ANY DAMAGED BY CONSTRUCTION OPERATION. LOCATE EXISTING UTILITIES PRIOR TO BEGINNING ANY EXCAVATION. UTILITY LOCATIONS SHOWN ARE APPROXIMATE. CALL BLUE STAKE (1-800-662-4111) PRIOR TO CONSTRUCTION.
4. LUMINAIRE CALL- OUTS ARE TO CENTER OF FOUNDATION. ADJUST LIGHT POLE, JUNCTION BOX LOCATIONS AS APPROVED BY ENGINEER TO AVOID CONFLICT WITH UTILITIES AND OTHER MAJOR FEATURES.
5. REFER TO UDOT STD. DWG. SL 11 & SL 12 FOR LUMINAIRE POLE INSTALLATION DETAILS. SEE SHEET LTDT-01 FOR A3 AND A4 POLE FOUNDATION DETAILS. CONSTRUCT TOP OF FOUNDATION FLUSH WITH EXISTING GROUND.
6. REFER TO UDOT STD. DWG. AT 7A FOR POLYMER CONCRETE JUNCTION BOX DETAILS.
7. POWER SOURCE:
   (A) EXISTING POWER SOURCE LOCATED AT THE BOTTOM OF I-80 EB OFF-RAMP. REMOVE EXISTING DISCONNECT PANEL AND PHOTO CELL FROM PED MOUNT TRANSFORMER. FURNISH AND INSTALL NEW LIGHTING PEDESTAL WITHIN 10 FT FROM TRANSFORMER AND INSTALL 3 INCHES SCHEDULE 40 PVC CONDUIT FROM LIGHTING PEDESTAL TO TRANSFORMER.
   (B) THIS PROJECT USE 480 VOLT SINGLE PHASE POWER.
8. BURY ALL NEW POLYMER CONCRETE JUNCTION BOXES 2" BELOW EXISTING GROUND AND INSTALL ONE POWER LOCATE BALL INSIDE EACH JUNCTION BOX.



N

LEGEND:

- STATE FURNISHED 40 FT SLIP BASE LUMINAIRE POLE W/ 15 FT ARM ASSEMBLY
- STATE FURNISHED 40 FT SLIP BASE LUMINAIRE POLE W/ 15 FT DUAL ARM ASSEMBLY
- LTG — TRENCHING WITH 2" SCHEDULE 40 PVC CONDUIT & WIRES
- NEW WIRES IN EXISTING CONDUIT
- DIRECTIONAL BORE WITH 2" HDPE CONDUIT & WIRES
- A1 — LIGHT POLE IDENTIFICATION
  A = CIRCUIT NUMBER
  1 = LIGHT POLE NUMBER
- PS — EXISTING POWER SOURCE
- LIGHTING PEDESTAL
- EXISTING JUNCTION BOX
- POLYMER CONCRETE JUNCTION BOX I-PC

REVISIONS

NO	DATE	APPROVED BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN

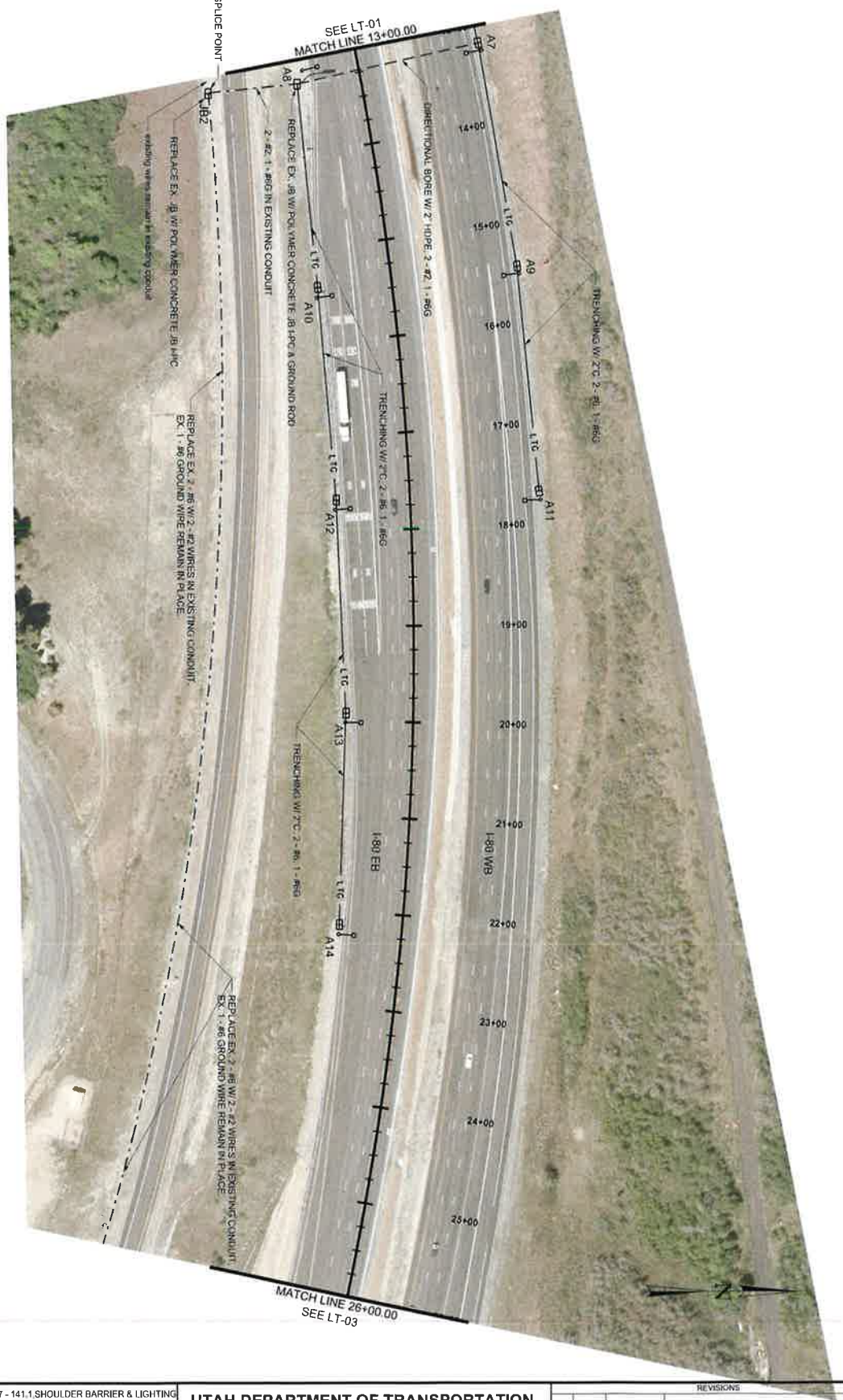
APPROVED

PROFESSIONAL ENGINEER

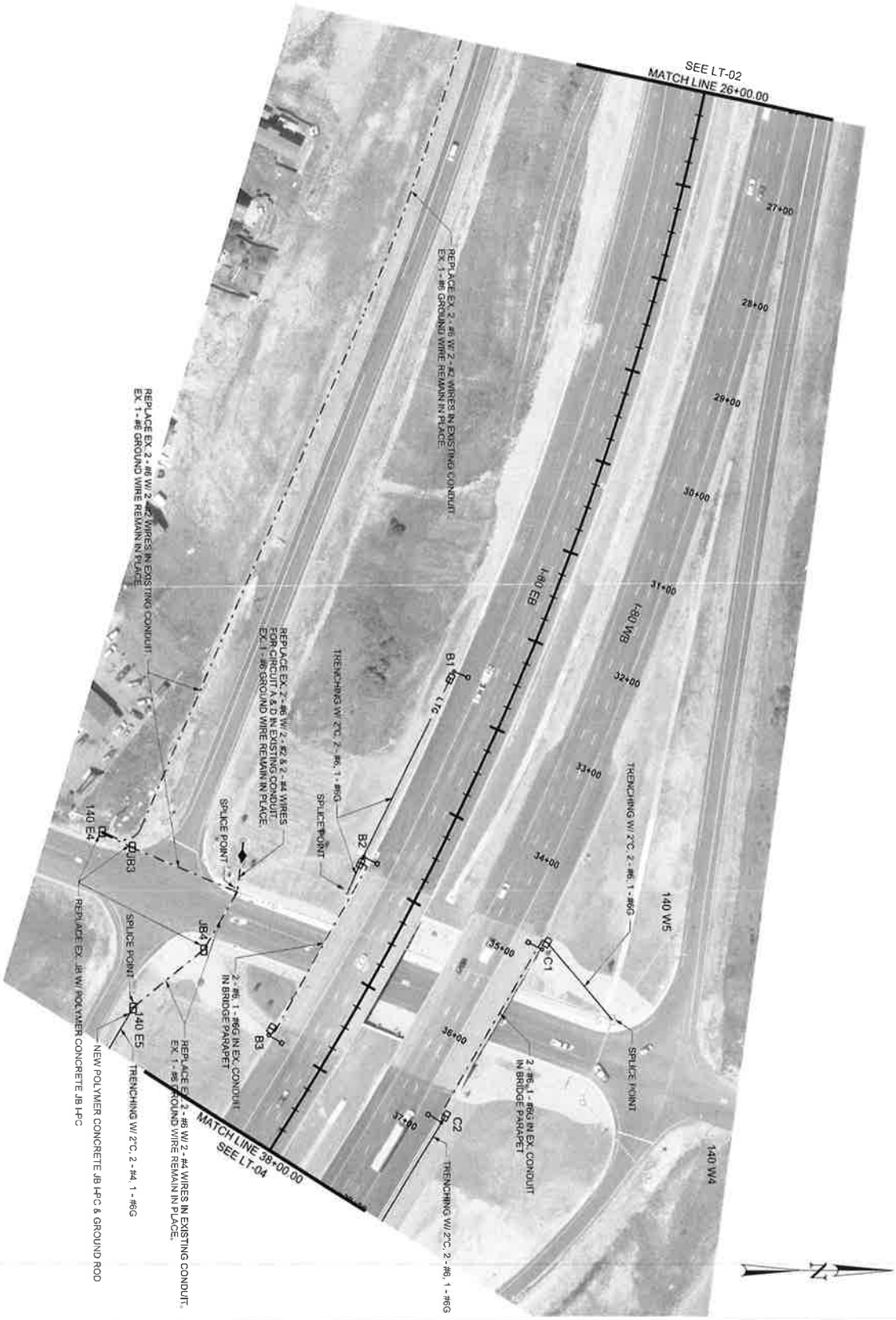
DRAWN BY RCC
QC CHECKED BY JRS
DATE 6/3/2015

PROJECT: I-80; MP 138.7 - 141.1,SHOULDER BARRIER & LIGHTING
I-80; PARLEY SUMMIT INTERCHANGE
PROJECT NUMBER: F-I80-4(157)140 PIN 13596
LIGHTING

SHEET NO. LT-01

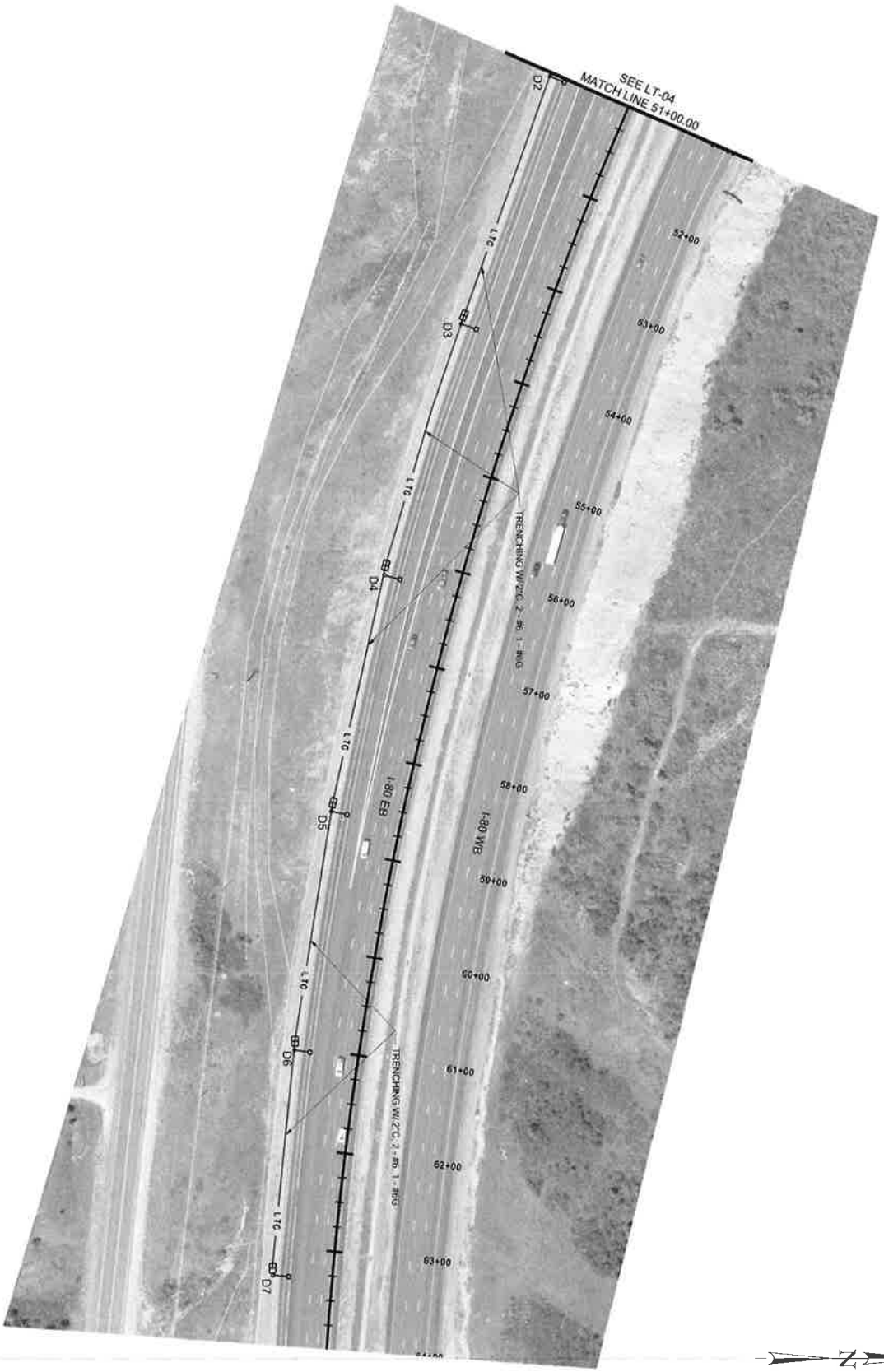


SHEET NO. LT-02	PROJECT	I-80; MP 138.7 - 141.1,SHOULDER BARRIER & LIGHTING		UTAH DEPARTMENT OF TRANSPORTATION		REVISIONS	
		I-80; PARLEY SUMMIT INTERCHANGE		DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN		NO.	DATE / APPROVED BY / REMARKS
	PROJECT NUMBER	F-I80-4(157)140	PIN 13596	APPROVED	DRAWN BY RCC		
		LIGHTING		PROFESSIONAL ENGINEER — DATE 6/3/2015	QC CHECKED BY JRS		



SHEET NO. LT-03	PROJECT	I-80; MP 138.7 - 141.1,SHOULDER BARRIER & LIGHTING	**UTAH DEPARTMENT OF TRANSPORTATION**		REVISIONS
		I-80; PARLEY SUMMIT INTERCHANGE	DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN		NO. DATE APPROVED BY REMARKS
	PROJECT NUMBER	F-I80-4(157)140 PIN 13596	APPROVED	DRAWN BY RCC	
		LIGHTING	PROFESSIONAL ENGINEER 6/3/2015 DATE	QC CHECKED BY JRS	

SHEET NO. LT-04	PROJECT	I-80; MP 138.7 - 141.1,SHOULDER BARRIER & LIGHTING	**UTAH DEPARTMENT OF TRANSPORTATION**		REVISIONS
		I-80; PARLEY SUMMIT INTERCHANGE	DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN		
	PROJECT NUMBER	F-I80-4(157)140 PIN 13596	APPROVED	DRAWN BY RCC	
		LIGHTING	PROFESSIONAL ENGINEER 6/3/2015 DATE	QC CHECKED BY JRS	NO. DATE APPROVED BY REMARKS



SHEET NO. LT-05	PROJECT	I-80; MP 138.7 - 141.1,SHOULDER BARRIER & LIGHTING	**UTAH DEPARTMENT OF TRANSPORTATION**			REVISIONS			
		I-80; PARLEY SUMMIT INTERCHANGE	DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN						
	PROJECT NUMBER	F-I80-4(157)140	PIN 13596	APPROVED	DRAWN BY RCC				
		LIGHTING		6/3/2015	QC CHECKED BY JRS	NO.	DATE	APPROVED BY	REMARKS
				PROFESSIONAL ENGINEER DATE					

I-80; MP 138.7 - 141.1 SHOULDER BARRIER LIGHTING SCHEDULE

POLE NO.	POLE IDENTIFICATION CODE	ALIGNMENT	STATION	OFFSET		POLE							LUMINAIRE 460 V LED TYPE B	POLYMER CONCRETE JUNCTION BOX, TYPE I-PC w/ POWER LOCATE BALL	3/4" X 10' COPPER COATED GROUND ROD	REMARKS
						40' SLIP BASE LUMINAIRE POLE	15' DUAL ARM	15' ARM	30" X 8' CONCRETE FOUNDATION	30" X 11' CONCRETE FOUNDATION	30" X 14' CONCRETE FOUNDATION	1" X 36" ANCHOR BOLT				
				LT	RT	EA		EA	EA	EA	EA	EA	EA	EA	EA	
140 E1	140 E1	I-80	2+83.74		65.43											EX. LUM POLE REMAINS
140 E2	140 E2	I-80	5+25.31		74.54											EX. LUM POLE REMAINS
140 E3	140 E3	I-80	7+65.00		83.85									1		EX. LUM POLE REMAINS, REPLACE EX. JB WITH JB I-PC
JB1		I-80	9+63.50		110.00									1		REPLACE EX. JB WITH JB I-PC
A1	140 W17	I-80	0+20.00	115.00		1		1	1			4	1	1	1	
A2	140 W16	I-80	2+00.00	134.00		1		1	1			4	1	1	1	
A3	140 W15	I-80	4+25.00	151.50		1		1			1	4	1	1	1	
A4	140 W14	I-80	6+50.00	155.00		1		1		1		4	1	1	1	
A5	140 W13	I-80	8+75.00	122.00		1		1	1			4	1	1	1	
A6	140 W12	I-80	11+00.00	126.50		1		1	1			4	1	1	1	
A7	140 W11	I-80	13+25.00	128.00		1		1	1			4	1	1	1	
A8	140 E6	I-80	13+11.00		58.60	1		1	1			4	1	1	1	INSTALL NEW POLE. REPLACE EX. JB WITH JB I-PC, INSTALL GROUNG ROD
JB2		I-80	13+15.00		158.50									1		REPLACE EX. JB WITH JB I-PC
A9	140 W10	I-80	15+50.00	132.30		1		1	1			4	1	1	1	
A10	140 E7	I-80	15+50.00		79.20	1		1	1			4	1	1	1	
A11	140 W9	I-80	17+75.00	135.50		1		1	1			4	1	1	1	
A12	140 E8	I-80	17+75.00		76.00	1		1	1			4	1	1	1	
A13	140 E9	I-80	20+00.00		70.00	1		1	1			4	1	1	1	
A14	140 E10	I-80	22+25.00		64.70	1		1	1			4	1	1	1	
JB3		I-80	35+93.00		267.00									1		REPLACE EX. JB WITH JB I-PC
JB4		I-80	36+52.00		168.50									1		REPLACE EX. JB WITH JB I-PC
140 E4	140 E4	I-80	36+02.91		320.20									1		REPLACE EX. JB WITH JB I-PC
140 E5	140 E5	I-80	37+53.80		204.00									1	1	INSTALL NEW JB, I-PC WITH GROUND ROD
B1	140 E11	I-80	32+60.00		66.20	1		1	1			4	1	1	1	
B2	140 E12	I-80	34+80.00		69.00	1		1	1			4	1	1	1	
B3	140 E13	I-80	36+95.00		65.00	1		1	1			4	1	1	1	
C1	140 W8	I-80	34+80.00	141.50		1		1	1			4	1	1	1	
C2	140 W7	I-80	36+80.00	137.70		1		1	1			4	1	1	1	
C3	140 W6	I-80	38+80.00	139.00		1		1	1			4	1	1	1	
JB5		I-80	42+94.00		138.60									1		NEW JB, I-PC
JB6		I-80	48+34.00		99.30									1		NEW JB, I-PC
D1	140 E14	I-80	48+40.00		54.30	1	1		1			4	2	1	1	
D2	140 E15	I-80	51+04.00		87.30	1		1	1			4	1	1	1	
D3	140 E16	I-80	53+64.00		78.30	1		1	1			4	1	1	1	
D4	140 E17	I-80	56+24.00		76.00	1		1	1			4	1	1	1	
D5	140 E18	I-80	58+64.00		70.80	1		1	1			4	1	1	1	
D6	140 E19	I-80	61+04.00		65.70	1		1	1			4	1	1	1	
D7	140 E20	I-80	63+29.00		61.00	1		1	1			4	1	1	1	
140 W1	140 W1	I-80	50+69.00	131.80												EX. LUM POLE REMAINS
140 W2	140 W2	I-80	48+08.50	143.50												EX. LUM POLE REMAINS
140 W3	140 W3	I-80	45+54.00	160.00												EX. LUM POLE REMAINS
140 W4	140 W4	I-80	35+67.40	384.10												EX. LUM POLE REMAINS
140 W5	140 W5	I-80	34+17.80	257.50												EX. LUM POLE REMAINS
TOTAL						27	1	26	25	1	1	108	28	36	28	
USE						*	*	*	**	**	**	*	*	**	**	

I-80; MP 138.7 - 141.1 SHOULDER BARRIER CIRCUIT SCHEDULE

CIRCUIT	LUMINAIRE POLES	SCHEDULE 40 PVC CONDUIT (FT)		RHH-USE2-RHW2 CABLE (FT)				FUSE (AMPS) EACH PHASE	BARE COPPER GROUND WIRE NO. 6 (FT)	BARE COPPER GROUND WIRE NO. 8 (FT)	TRENCHING & BACKFILL (FT)	DIRECTIONAL BORE W/2" HDPE CONDUIT (FT)	LIGHTING PEDESTAL (EA)	POWER SOURCE & HOOKUP(EA)	REMARKS
		2"	3"	NO. 2	NO. 4	NO. 6	NO. 8								
A	14	2,669	10	5,250		5,422	1,904	20	3,018	182	2,679	200			
B	3	280				1,014	408	20	507	39	280		1	1	
C	3	360				1,144	408	20	572	39	360				
D	7	2,601			2,696	2,684	1,046	20	2,690	91	2,601	50			
TOTAL	27	5,910	10	5,250	2,696	10,264	3,766		6,784	351	5,920	250	1	1	
USE	*	**	**	**	**	**	**	**	**	**	**	**	**	**	

* STATE FURNISHED MATERIALS, INSTALLED BY CONTRACTOR. COST COMBINED IN ESTIMATE AS HIGHWAY LIGHTING SYSTEM.
** CONTRACTOR FURNISHED AND INSTALLED ITEMS. COST COMBINED IN ESTIMATE AS HIGHWAY LIGHTING SYSTEM.

REVISIONS

NO.	DATE	APPROVED BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN

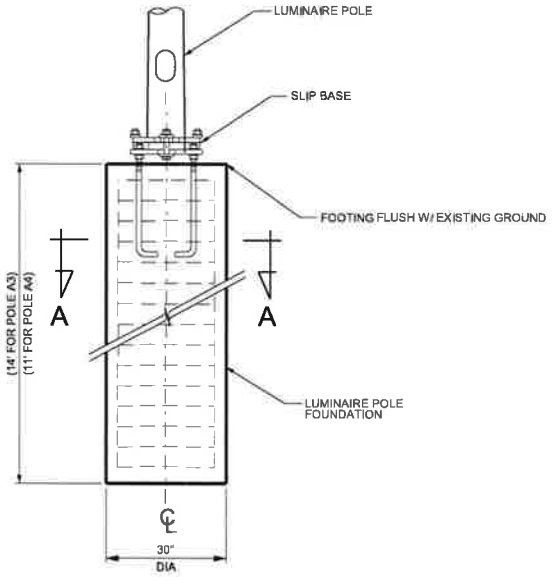
DRAWN BY: RCC
QC CHECKED BY: JRS
APPROVED
PROFESSIONAL ENGINEER
DATE: 6/3/2015

I-80; MP 138.7 - 141.1 SHOULDER BARRIER & LIGHTING

PROJECT: I-80; PARLEY SUMMIT INTERCHANGE
PROJECT NUMBER: F-I80-4(157)140 PIN 13596

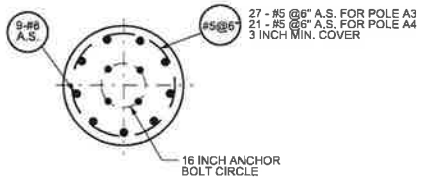
LIGHTING SCHEDULE

SHEET NO. LT-06



A3 & A4 LUMINAIRE POLE FOUNDATION DETAIL

A3 STA 4+25.00
A4 STA 6+50.00



A - A DETAIL

TRENCHING DETAIL

1. PROVIDE MINIMUM COVER FOR ALL ROADWAY CROSSINGS : 24 " FOR CONDUIT PLACED IN TRENCH; 36" FOR DIRECTIONAL BORE CONDUIT.
2. MAINTAIN 12" VERTICAL SEPARATION FROM ALL EXISTING UTILITY LINES. MAINTAIN 36" HORIZONTAL SEPARATION FROM ALL GAS LINES.
3. PROVIDE 18" MINIMUM COVER FOR CONDUIT PLACED OFF ROADWAY WITHOUT CONCRETE ENCASEMENT OR CAPPING.
4. PROVIDE 12" MINIMUM COVER FOR CONDUIT PLACED OFF ROADWAY WITH CONCRETE ENCASEMENT OR MINIMUM 2" THICK CONCRETE CAPPING.

REVISIONS

NO.	DATE	APPROVED BY	REMARKS

UTAH DEPARTMENT OF TRANSPORTATION
DIVISION OF TRAFFIC AND SAFETY - SIGNAL AND LIGHTING DESIGN

DRAWN BY: RCC
QC CHECKED BY: JRB
APPROVED
PROFESSIONAL ENGINEER
DATE: 6/3/2015

PROJECT: I-80; MP 138.7 - 141.1,SHOULDER BARRIER & LIGHTING
I-80; PARLEY SUMMIT INTERCHANGE
PROJECT NUMBER: F-I80-4(157)140 PIN 13596
LIGHTING DETAIL

SHEET NO. LTDT-01